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An Observation Study of Irrigator Activities, 2002-2003

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Bernardo Hernandez, Associate Environmental Research Scientist
Greg Boers, Environmental Research Scientist
Saturnino Yanga, Associate Environmental Research Scientist

Department of Pesticide Regulation
California Environmental Protection Agency
1001 I Street, Sacramento, California 95814-5624

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Executive Summary

Objective: The study focus was observation of typical irrigator activities during normal irrigation work practices, and documentation of the time spent on each irrigation task as well as the time spent in foliar contact. The information gathered will be used to evaluate the exposure potential of irrigators and may be used to guide future studies.

Methods: Components of the study included grower's discussions regarding irrigation practices and observing and timing irrigator activities to evaluate potential exposure in irrigated crops.

Results: Twenty-nine irrigators were observed as part of this study and used in the analysis. In addition, three irrigators were observed as a pilot project to test the methods and were not used in the analysis. Of the 29, 13 were furrow irrigation workers and 16 sprinkler irrigation workers.

Furrow irrigators work an average of 10 hours per workday. An average of 1.5 hours involved foliar contact and 8.5 hours did not involve foliar contact while performing other irrigation activities such as ditch tending, movement of tarps, siphon tubes, gated-main pipes, etc. The 16 sprinkler irrigators averaged a 9.2-hour workday. The average time of foliar contact activities was 2.7 hours, while an average of 6.5 hours involved minimal or no foliar contact while performing other irrigation tasks, such as loading and unloading irrigation pipe from trailers.

Working around water, irrigators experience wetness to varying degrees. Furrow irrigators were observed spending a majority of the time working the periphery of fields. While performing these irrigation activities, the workers constantly got their hands wet. This may result in washing or rubbing pesticide residues off their hands, and thus possibly decreasing the amount of potential pesticide exposure. Sprinkler irrigators are wet from their shoes to mid-chest. The degree of wetness to the worker's clothing is dependent on a worker's height in relation to the height of the crop being irrigated. Particularly in taller crops such as cotton, the workers' skin and clothing get very wet. The effect on pesticide residues in contact with wet skin and/or clothing is unknown. The Worker Health and Safety Branch plans to conduct an exposure monitoring study of irrigators to evaluate dermal exposure to furrow and sprinkler irrigators in cotton during 2006.

None of the irrigators observed entered a field prior to the expiration of a pesticide's restricted entry interval (REI).

Background

Data from the Department of Pesticide Regulation Pesticide Illness Surveillance Program (PISP) database of pesticide-related illnesses and injuries from 1996 through 2004 found 113 illnesses and injury cases involving irrigators[1,2]. Of the 113 cases, 6 cases involved direct contact with pesticide spray or splash; 74 involved exposure to residue (27 residue exposures involved early entry into the field); while 30 were the result of drift exposure; two had multiple exposure routes while the exposure for one irrigator was unknown. The Worker Health and Safety Branch (WHS) periodically compiles reports on the pesticide-related occupational illnesses and injuries of irrigators[3,4,5]. However, WHS has not fully evaluated the types of activities irrigators typically engage in and the extent of potential pesticide exposure related to these activities. Periodic surveys are needed to assess current irrigation techniques, the extent of foliar contact and the types of residues to which this population is exposed.

The basic types of irrigation systems are:

- *Surface irrigation* – Water is applied in furrows or basins or flooded over the surface and is supplied through pumps, gates, siphon tubes and/or gated pipes. Photos 1 and 2 are examples of furrow irrigations.

Photo 1. Furrow Irrigation, Siphons tubes

Photo 2. Furrow Irrigation, Gated pipe

- *Sprinkler irrigation* - Water is supplied under pressure and distributed through sprinklers that include hand-moved sprinklers, center-pivots, side-rolls, traveling guns, boom sprinklers, traveling lateral systems, etc. Photo 3 shows sprinkler irrigation.

Photo 3. Sprinkler Irrigation

- *Drip irrigation* - Water is delivered at very low pressure through buried or surface lay mains and sub-mains of PVC tubing. A network of drip outlet emitters carry water from the sub-mains to plant roots. Photo 4 shows drip irrigation

Photo 4. Drip Irrigation in Lettuce

The State of California, Department of Pesticide Regulation, WHS evaluated typical irrigator activities during normal irrigation work practices. This observation study provides real-time data. Without real-time data, WHS relies on conservative default values to estimate exposure. These observations will provide a basis for determining the exposure potential to irrigators and may be of value in making risk mitigation determinations. WHS staff conducted observations of two types of irrigation systems: furrow and hand-moved sprinkler. Staff observed and documented the amount of time irrigators spent doing each activity (i.e., enter fields, foliar contact, pipe contact, etc.) for an irrigator typical workday, minimum of four hours and maximum of generally 8 to 10 hours.

Methods & Materials

Contacting Growers and Prospective Participants:

With the aid of the County Agricultural Commissioner's staff, study personnel contacted growers from Fresno, Colusa and Monterey counties. Prospective participants were irrigators who work directly for the grower or were hired by a labor contractor and whose primary duties are irrigation tasks. The irrigators were not approached unless the grower had granted WHS permission to conduct the study.

Crops and Irrigation Systems:

Target crops included cole crops, cotton, artichokes and tomatoes irrigated by furrow and/or hand-moved sprinkler systems. These crops were selected because of the fullness of their leaf canopy and the high foliar contact potential.

Irrigator Observations:

The study population consisted of irrigators employed to irrigate by using either furrow or hand-moved sprinkler systems. The study goal was to observe and document at least 5 workers in three different crop/irrigation system combinations. The crop/irrigation system combinations observed in this study included furrow-irrigated cotton, furrow-irrigated tomato, furrow-irrigated broccoli, sprinkler-irrigated cotton, sprinkler-irrigated tomato and sprinkler-irrigated artichokes. A list of the workers observed, the crop/irrigation system combination they were involved in and the crop heights are given in Table 1.

Grower/Ranch contact information, as well as crop information (field location/size, crop height/maturity, field condition, application history, etc.) was obtained prior to observing workers.

Workers were observed for a minimum of 4 hours and a maximum of 12.3 hours. This duration corresponds to a full workday for the irrigator under observation. The activities of each worker were observed throughout their workday. Each activity was recorded on an Irrigator Task/Time Tracking sheet (Figure 1). This tracking sheet allows for recording the following: worker apparel, any PPE (personal protective equipment) worn, irrigator task and duration of each task. Photographs were also taken to document field maturity, crop type and a worker's potential exposure. Photographs were taken so as to obscure the identity of the worker.

Study staff did not interfere with irrigator activities nor did they question, interview, or document personal information.

Table 1. Observed Workers, Irrigation/Crop System and Crop Height

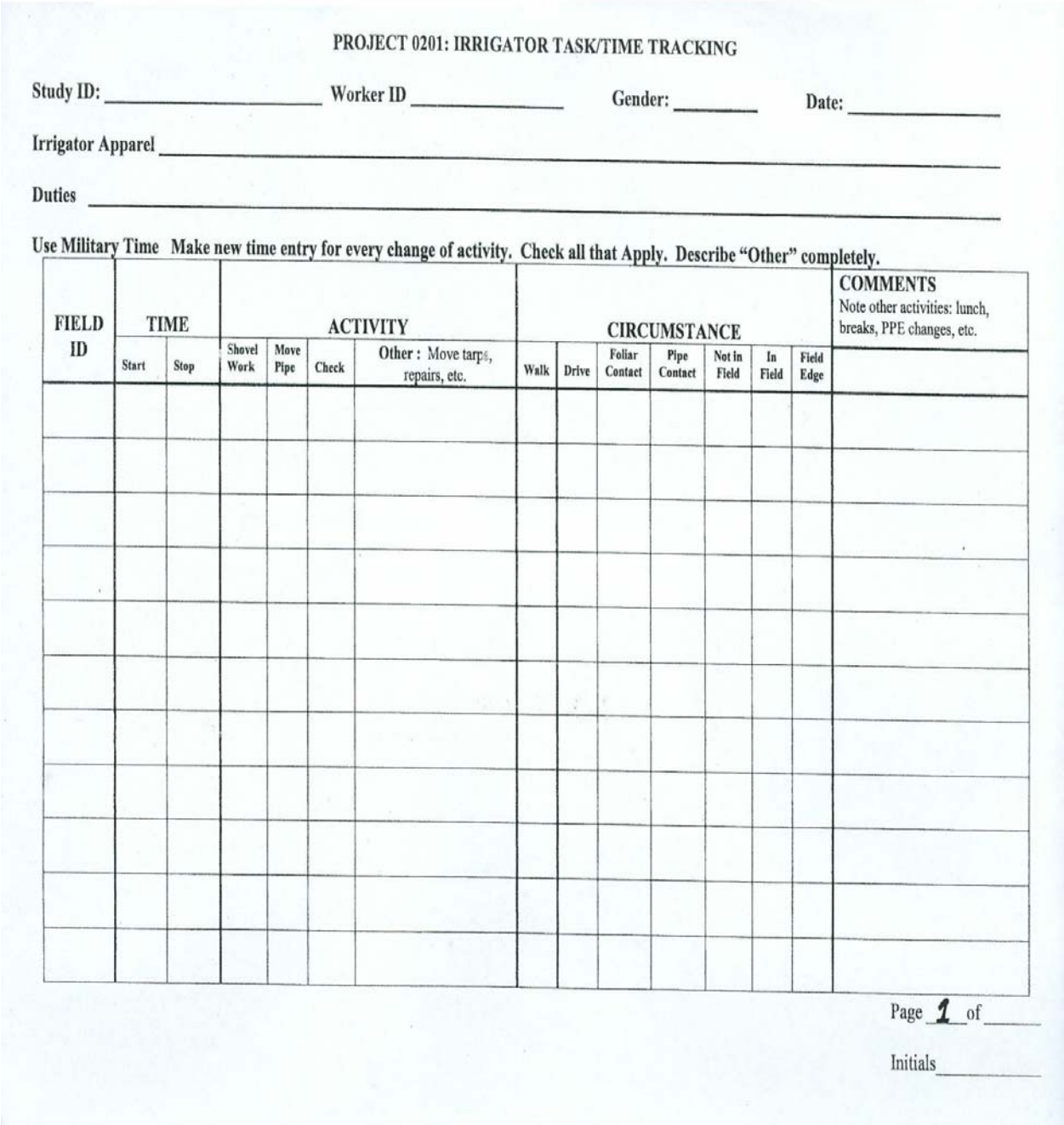
StudyID[1]	WorkerID[2]	Irrigation Type	Crop	Crop Height (inches)
CW01	01	Furrow	Tomato	18
CW02	02	Furrow	Cotton	54
CW03	03	Furrow	Tomato	18
CW04	04	Furrow	Cotton	54
CW05	05	Furrow	Cotton	36
CW06	06	Furrow	Cotton	36
WE07	07[3]	Sprinkler	Tomato	30
WE08	08[3]	Sprinkler	Tomato	30
WE09	09[3]	Sprinkler	Tomato	36
WE10	10[3]	Sprinkler	Tomato	36
WE12	12	Sprinkler	Cotton	36
SM13	13	Sprinkler	Artichokes	24
SM14	14	Sprinkler	Artichokes	18
SM5	15	Sprinkler	Artichokes	18
SM16	16	Sprinkler	Artichoke	18
SM17	17	Sprinkler	Artichokes	18
AF18	18	Furrow	Broccoli	36
WE19	19	Sprinkler	Tomato	18
AF20	20	Furrow	Broccoli	36
WE21	21	Sprinkler	Tomato	24
AF22	22	Furrow	Broccoli	24
WE23	23	Sprinkler	Tomato	24
AF24	24	Furrow	Broccoli	24
WE25	25	Sprinkler	Tomato	24
WE26	26	Furrow	Broccoli	36
BF27	27	Furrow	Cotton	50
AF28	28	Furrow	Broccoli	36
AF29	29	Sprinkler	Broccoli	30
AF30	30	Sprinkler	Broccoli	23

1 – Study ID – Represents the trial number.

2 – Worker ID – Identification given to each worker participating in the study. Workers 11, 31 and 32 were observed, but were not included in the study as the observations were made during a trial run to test the data collection instrument.

3 - Workers 7, 8, 9 and 10 were also involved in furrow irrigation activities but these activities were not directly related to the irrigation itself. For the purpose of analysis, only their sprinkler irrigation work hours were considered.

Figure 1. Irrigator Task/Time Tracking Sheet



PROJECT 0201: IRRIGATOR TASK/TIME TRACKING

Study ID: _____ Worker ID _____ Gender: _____ Date: _____

Irrigator Apparel _____

Duties _____

Use Military Time Make new time entry for every change of activity. Check all that Apply. Describe "Other" completely.

FIELD ID	TIME		ACTIVITY				CIRCUMSTANCE							COMMENTS Note other activities: lunch, breaks, PPE changes, etc.
	Start	Stop	Shovel Work	Move Pipe	Check	Other : Move tarps, repairs, etc.	Walk	Drive	Foliar Contact	Pipe Contact	Not in Field	In Field	Field Edge	

Page 1 of _____

Initials _____

Dislodgeable Foliar Residue (DFR) Sampling:

Although the study protocol stated that DFR sampling would be conducted, DFR samples were not collected during irrigator observations since field histories indicated that pesticides had not been applied within five days prior to the irrigator observations.

Data Treatment and Analysis:

Raw data was entered into a Microsoft Access® 2000 database. Microsoft Excel® 2000 was also used to analyze data and generate graphs. Data analysis was restricted to workers who could be classified as working exclusively on only one type of irrigation practice.

The time, in minutes, that each worker spent on any one activity was summed. For example, if a furrow irrigator had performed shovel work from 6:15 a.m– 6:20 a.m. (5 minutes), 6:46 a.m. – 7:00 a.m. (14 minutes) and from 9:25 a.m. – 11:25 a.m. (120 minutes), his total "shovel work" for the day was recorded as 139 minutes.

Observations were grouped on the basis of: (a) the type of irrigation practiced at the study site (furrow or sprinkler), (b) whether or not a worker had foliar contact, and (c) if the worker was involved in furrow, sprinkler or non-irrigation activity during the observation. Table 2 lists the observed activities associated with foliar contact while Table 3 lists the observed activities that were not associated with foliar contact. Both tables take into account the location where these activities were performed.

Table 2. Irrigator Activities Associated with Foliar Contact

Location	Irrigation Type	
	Furrow Irrigation	Sprinkler Irrigation
In field	Field check (location of water in row), shovel work, (clearing obstructions & directing flow)	Moving irrigation pipe, pipe (main[1] or sprinkler) removal from field

[1] Main water supply line that feed gated pipe or sprinkler pipe. Mains can either be located on the field edge or may sometimes run the middle of the field.

Table 3. Irrigator Activities Not Associated with Foliar Contact

Location	Irrigation Type	
	Furrow Irrigation	Sprinkler Irrigation
Field edge	Handling siphon tubes and tarps or gated main pipe[1], shovel work (clearing obstruction & directing flow)	Connecting or disconnecting main[1]
Not in field	Breaks (morning, lunch, afternoon), counting pipes for next irrigation set	Breaks, (morning, lunch, afternoon)
In field		Connecting pipes (mains[1] or sprinkler) in fallow or newly planted field, (plant under 6 inches tall

[1] Main water supply line that feed gated pipe or sprinkler pipe. Mains can either be located on the field edge or may sometimes run the middle of the field.

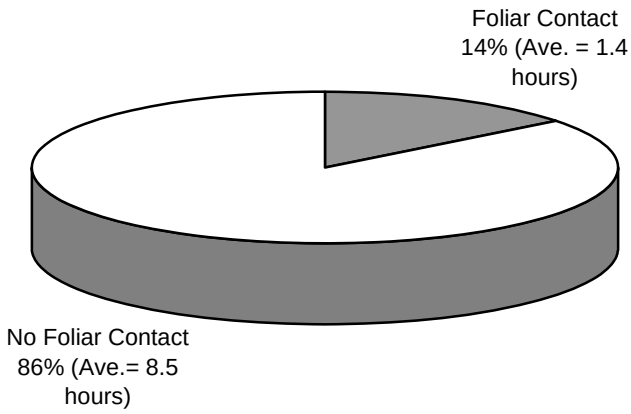
After calculating the total time a worker spent on any one activity (*i.e.* shovel work); the total time of activities associated with furrow, sprinkler or non-irrigation activities was determined. Averages were calculated for furrow, sprinkler and non-irrigation activities associated with and without foliar contact. Time in minutes was converted to hours for ease in data interpretation.

Results

Thirty-two irrigators were observed for this study. Three irrigators were excluded from data analyses because they were initially observed to test the observation procedures and evaluate the utility of the observation forms created for recording worker activities. The evaluation process included comparing notes, agreeing on what staff had witnessed, determining task duration (i.e. time allowed prior to decision of new work task), and modifying the forms each day until reaching the finished product. Of the 29 irrigators used in the analysis, 13 (45 %) were furrow irrigation workers and 16 (55%) were sprinkler irrigation workers. None of the irrigators observed in this study entered fields prior to the expiration of a pesticide's restricted entry interval (REI).

The average workday for furrow irrigators was 9.9 hours, ranging from 4.6 to 12.3 hours. The average number of foliar contact hours attributed to furrow irrigation activities was 1.4 hours (14 % of average work hours) while the average no-foliar contact hours attributed to other activities was 8.5 hours (86 % of average work hours) (Figure 2).

Figure 2. Foliar vs. No Foliar Contact, Furrow Irrigators (n=13)



Furrow irrigators were observed performing irrigation activities alone most of the time (Photos 5, 6, and 7)

Photo 5. Furrow Irrigator Carrying Siphon Pipes Alone.

Photo 6. Furrow Irrigator Conducting a Field Check Alone.

Photo 7. Furrow Irrigator, Working Alone, with Irrigation Socks.

Furrow irrigators wore appropriate protective attire including knee or thigh high rubber boots, rain pants and long sleeve shirt and/or jacket (Photo 8). Their hands were wet a majority of the time, potentially affecting the amount of pesticide exposure to the hands (Photo 9). Furrow irrigators were observed spending a minimal amount of time in the field and a majority of the time working the periphery of field (i.e. tending the water from the field edge and preparing for the next water change).

Photo 8. Example of Apparel Worn by a Furrow Irrigator.

Photo 9. Irrigator Working with Siphon Tubes.

Source: http://www.livinghistoryfarm.org/farminginthe30s/water_20.html

Figure 3 illustrates the relative time each furrow irrigator spent on activities involving foliar contact as opposed to activities that did not involve foliar contact.

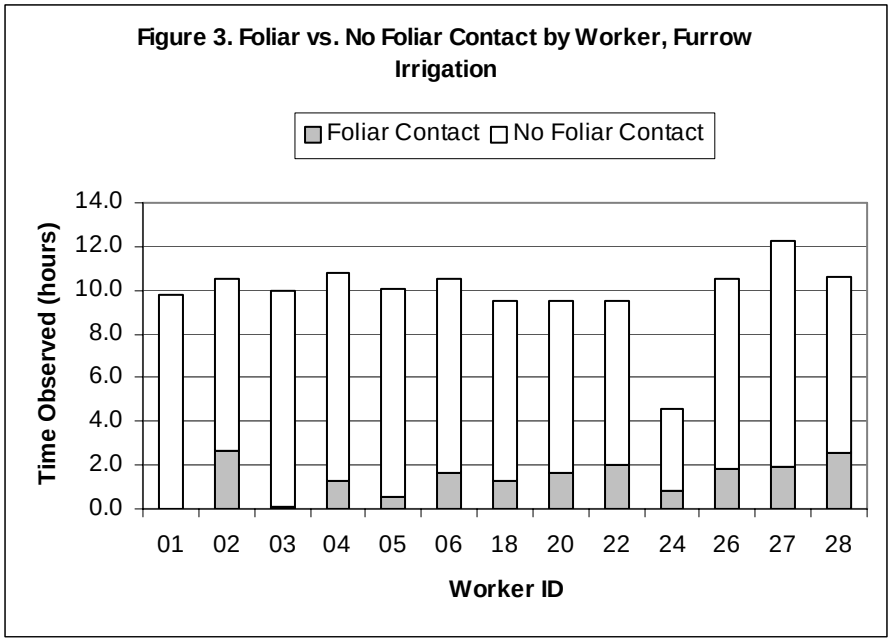


Table 2 summarizes the breakdown of time observed per furrow irrigator after grouping by foliar contact and type of activity (irrigation vs. non-irrigation).

Table 2. Breakdown of Time Observed Per Worker, Furrow Irrigation

Worker ID[1]	Crop	Time Observed (hours)	Foliar Contact[2] (hours)	No Foliar Contact[3] (hours)
01	Tomato	9.8	0.0	9.8
02	Cotton	10.5	2.6	7.9
03	Tomato	10.0	0.1	9.9
04	Cotton	10.8	1.3	9.5
05	Cotton	10.1	0.6	9.5
06	Cotton	10.5	1.7	8.8
18	Broccoli	9.5	1.3	8.2
20	Broccoli	9.5	1.7	7.9
22	Broccoli	9.5	2.0	7.5
24	Broccoli	4.6	0.9	3.7
26	Broccoli	10.5	1.8	8.7
27	Cotton	12.3	2.0	10.3
28	Broccoli	10.6	2.6	8.0
Sum		128.1	18.5	109.7
Minimum		4.6	0.0	3.7
Maximum		12.3	2.6	10.3
Average		9.9	1.4	8.4
Standard Deviation		1.7	0.8	1.7
Count		13	13	13

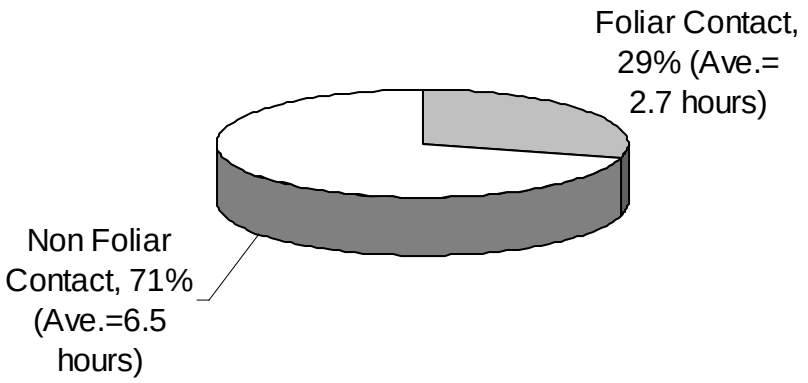
1 - Worker ID – Identification given to each worker participating in the study

2 – Setting siphon tubes, opening gates on gated pipe, in field directing water flow, in field to note water progression, etc.

3 - Morning calisthenics, breaks (a.m., lunch, p.m.), traveling (to and from field, around field, to shop), and conversations with irrigator foreman on field edge, etc

The average workday for sprinkler irrigators was 9.2 hours ranging from 4.9 to 11.8 hours. The average number of hours of foliar contact attributed to sprinkler irrigation activities involving water movement was 2.7 hours (29% of average work hours) while the average total hours of no foliar contact attributed to other activities was 6.5 hours (71% of average work hours) (Figure 4).

Figure 4. Foliar vs. Non Foliar Contact, Sprinkler Irrigation (n=16)



Sprinkler irrigators were observed to conduct tasks that may or may not involve water movement and/or foliar contact. Activities that involve water movement and foliar contact are moving and checking sprinkler pipes. Activities that involve foliar contact without water movement include removing pipes (main lines or sprinkler) from the field because water flow has ceased. Activities involving water movement without foliar contact were observed in fields that were recently planted or had small crops (<6 inches). Activities without foliar contact and not involving water movement include morning calisthenics, travel to and from the field, breaks and lunch

Sprinkler movers were observed to wear various protective attire including rain pants, rubber gloves, tennis shoes or rubber boots, long sleeve shirts, jackets, sweatshirts and back braces (Photos 10). These workers would get wet from their feet to mid-chest, depending on their own height and that of the crop being irrigated (Photos 11).

Photo 10 - Example of Apparel Worn by a Sprinkler Irrigator, Including Back Brace.

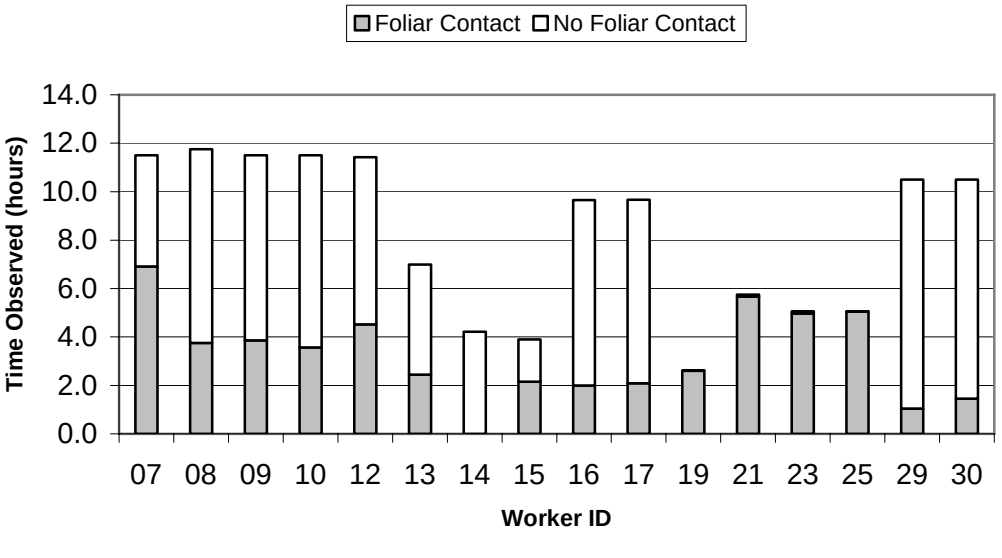
Photos 11. Sprinkler Irrigators Showing Varying Degrees of Wetness on Apparel

Unlike furrow irrigators who may work alone, sprinkler movers worked in groups of three or four (Photo 12).

Photo 12. Sprinkler Irrigators Working in Groups.

Figure 5 illustrates the relative time each sprinkler irrigator spent on activities involving foliar contact as opposed to activities that did not involve foliar contact. Workers 21, 23 and 25 worked two shifts, taking approximately a six-hour break in between shifts. These six hours were not included as part of these worker's workday.

Figure 5. Foliar vs. No Foliar Contact by Worker, Sprinkler Irrigation



Sprinkler irrigators also performed other duties associated with irrigation about the farm (Photos 13, 14), including gated pipe installation for furrow irrigation (Photo 15).

Photo 13. Other Sprinkler Irrigator Tasks: Loading Pipes

Photo 14. Other Sprinkler Irrigator Tasks: Setting Pipes in a New Field

Photo 15. Other Tasks: Sprinkler Irrigators Loading Gated Mainline Pipes, Left at Field Edge, for Furrow Irrigation.

Table 3 summarizes the breakdown of time observed per sprinkler irrigator after grouping by foliar contact and type of activity (irrigation vs. non-irrigation).

Table 3. Breakdown of Time Observed Per Worker, Sprinkler Irrigation

			FOLIAR CONTACT		NO FOLIAR CONTACT		Total Hours of Foliar Contact Attributed to Sprinkler Irrigation Activities	Total Hours of No Foliar Contact – All Other Activities
Worker ID[1]	Crop	Time Observed (hours)	Activities Involving Water Movement[2] (hours)	Activities NOT Involving Water Movement[3] (hours)	Activities Involving Water Movement[4] (hours)	Activities NOT Involving Water Movement[5] (hours)		
07	Tomato	11.5	6.9	0.0	0.0	4.6	6.9	4.6
08	Tomato	11.8	3.8	0.0	1.1	6.9	3.8	8.0
09	Tomato	11.5	3.9	1.8	0.0	5.8	3.9	7.6
10	Tomato	11.5	3.6	2.1	0.0	5.8	3.6	7.9
12	Cotton	11.4	4.5	2.0	0.0	4.9	4.5	6.9
13	Artichoke	9.0	0.0	0.0	3.4	5.6	0.0	9.0
14	Artichoke	8.7	0.0	0.0	3.7	4.5	0.0	8.7
15	Artichoke	8.6	0.0	0.0	3.1	5.0	0.0	8.6
16	Artichoke	10.4	0.0	0.0	7.1	3.3	0.0	10.4
17	Artichoke	10.5	0.0	0.0	6.0	4.5	0.0	10.5
19	Tomato	4.9	4.0	0.4	0.5	0.0	4.0	0.9
21	Tomato	5.8	5.0	0.7	0.0	0.1	5.0	0.8
23	Tomato	5.1	4.2	0.8	0.0	0.1	4.2	0.9
25	Tomato	5.1	4.3	0.7	0.0	0.1	4.3	0.8
29	Broccoli	10.5	1.4	0.1	3.6	5.4	1.4	9.1
30	Tomato	10.5	1.5	0.3	1.6	7.2	1.5	9.0
	Sum (hrs)	146.7	43.2	8.6	33.7	61.2	43.2	103.5
	Minimum (hrs)	4.9	0	0	0	0	0	0.8
	Maximum (hrs)	11.8	6.9	2.1	7.1	6.9	6.9	10.5
	Average (hrs)	9.2	2.7	0.5	2.1	3.8	2.7	6.5
	Standard Deviation	2.6	2.2	0.8	2.5	2.4	2.2	3.6
	Count	16	16	16	16	16	16	16

1 – Worker ID – Identification given to each worker participating in the study
2 – Move sprinkler pipes, checking sprinkler pipes
3 – Removal of pipes from field
4 – Crops were small (<6 inches); Workers wore boots
5 – Morning calisthenics, breaks (a.m., lunch, p.m.) traveling (to and from field, around field, to shop), etc.

A fair amount of preparation time is involved in setting up an irrigation system before actual irrigation can take place. It usually takes time to reconnect the mainline supplying the water to the field (Photos 16 and 17) or for irrigation water to be redirected into ditches for irrigation purposes (Photos 18 and 19).

Photo 16. Furrow Irrigation Pipes to be Reconnected

Photo 17. Sprinkler Irrigation Pipes to be Reconnected

Photo 18. Water Being Redirected into Ditches for Furrow Irrigation

Photo 19. Pipes in Field Waiting for Water in Furrow Irrigation

Discussion

Most California crops are irrigated. It has been estimated that California's farm labor force ranges from 500,000 to more than one million workers[6], of which an unknown number are irrigators. For the risk assessment process, DPR generally assumes that irrigator exposure is negligible when compared to other post-application work activities such as harvesting or thinning. However, little documentation is available for either irrigator activities or their potential pesticide exposure.

The focus of this study was to evaluate the time irrigators spend contacting treated foliage when performing tasks related to either furrow or hand-moved sprinkler irrigation systems. This study demonstrates that irrigators experience relatively short foliar contact periods (average of 1.4 and 2.7 hrs/day for furrow and sprinkler irrigators, respectively). In comparison, field workers are often in continual contact with foliage for 7-9.5 hours per day in crops such as lemons, peaches and greenhouse ornamentals[7-10].

Furrow irrigators spent the majority of their time controlling water flow from the periphery of field. They typically wear rubber boots (knee or thigh high), rain pants, long sleeved shirts and/or a jacket. They generally stay dry except for their hands, which are frequently immersed in water. This may result in washing or rubbing off pesticide residue, thus possibly decreasing the amount of pesticide exposure these workers receive.

Since sprinkler irrigators work in foliage that is continuously wet, they often wear waterproof clothing and/or several layers of clothing; footwear varies and includes either tennis shoes or rubber boots. A sprinkler irrigator may be wet from his feet up to the mid-chest, depending on his own height, the height of the crop being irrigated, and the type of waterproof clothing worn. Because the crop foliage is wet, pesticide concentrations found in sprinkler irrigated crops, may be lower than those found furrow-irrigated crops.

In addition to pesticide exposure via foliar contact, furrow and sprinklers irrigators could potentially be exposed to pesticide residues while handling irrigation pipe. In this study, the duration of pipe contact was not timed. More research is needed to measure irrigators' actual pesticide exposure.

WHS plans to conduct an exposure monitoring study of both furrow and sprinkler irrigators in cotton. The study will provide dermal exposure data and may increase our understanding of the extent that irrigator's extra clothing, wet working conditions and limited time spent in foliar contact affect their exposure. These data will assist DPR in developing appropriate exposure estimates for irrigators.

California regulations (California Code of Regulations Title 3 [3CCR], Section 6770)[(11)] allow early entry exemptions for irrigation and other low-contact activities. If early entry is required, employers must adhere to requirements in 3 CCR, Section 6771[(12)] for early entry workers. According to limited informal interviews with growers (of tomatoes, cotton, broccoli and artichokes) conducted in conjunction with this project, it is rare for an irrigator to be required to enter a field prior the expiration of the REI. None of the

irrigators in this study entered fields during REIs. Further study is needed to determine the extent of irrigator reentry during the REI in these and other crops.

Study staff observed the irrigator foreman or his assistant checking on the irrigators several times throughout the workday to ensure both their safety and compliance with work rules. As discussed above, even entering fields after the expiration of the REI, most irrigators in this study wore apparel that provided some level of protection from cool temperatures and wetness, and thus, from direct foliar contact.

PISP reported 113 illnesses/injuries of irrigators between 1996 and 2004. Forty-six of these (41%) involved skin injuries such as rash, itchiness, irritation, redness, numbness and burning sensations. The remaining 67 cases (59%) did not involve skin illness/injuries; they involved eye injuries, systemic symptoms and respiratory problems. According to Held *et al.* [13] skin diseases account for as much as 30% of all occupational diseases, and employees in wet occupations are at increased risk of developing irritant skin reactions. The constant wet conditions that an irrigator is subjected to may contribute to the reported skin injuries.

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